

# DSP

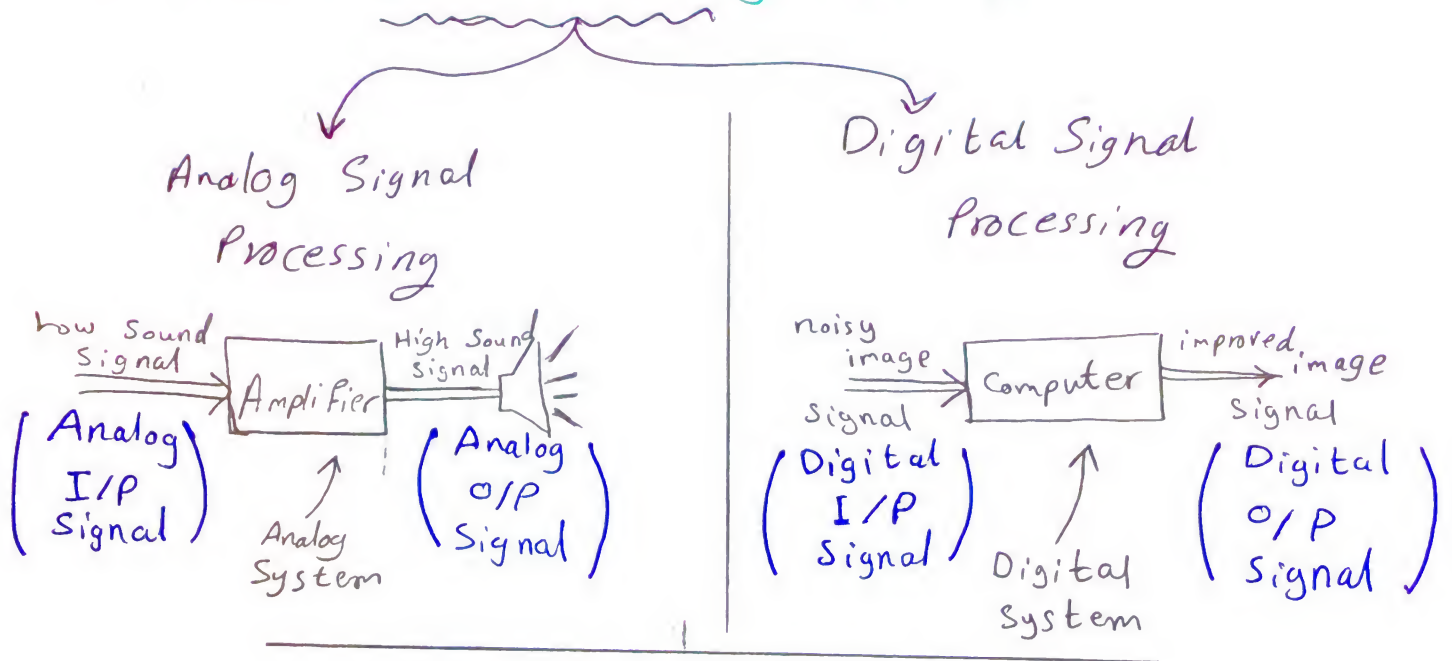
1/10/2015

الخمس

د. محمد عرفة

مادة 1

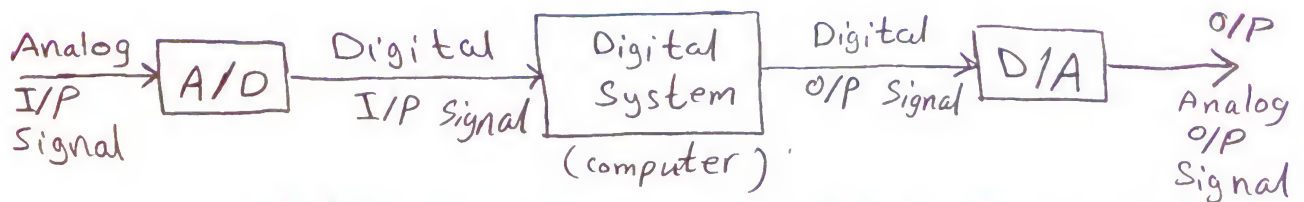
## Digital Signal Processing (DSP)



### \* Advantages of DSP :-

- ① more flexible
- ② more Accurate
- ③ easy to store
- ④ easy to update

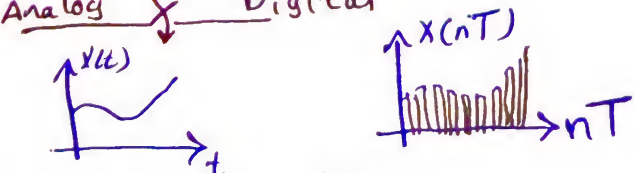
### \* The Basic elements of DSP :-



A/D  $\equiv$  Analog to Digital Converter.

D/A  $\equiv$  Digital to Analog Converter.

A/D  $\equiv$  Sampler  
Analog  $\times$  Digital



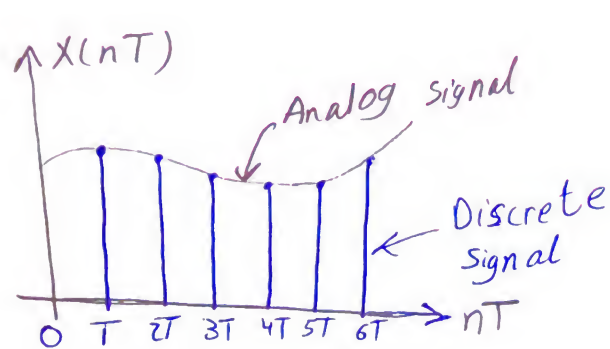
$T \Rightarrow$  Sampling time  
 $n \Rightarrow$  Sampling no. ( $n = 0, 1, 2, 3, \dots$ )

$$x(nT) = x(t) \Big|_{t=nT}$$

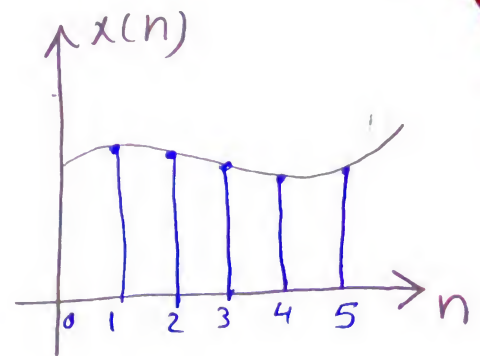
Assume  $T = 1 \text{ sec}$

$$x(n) = x(t) \Big|_{t=n \text{ (sampling No.)}}$$

①



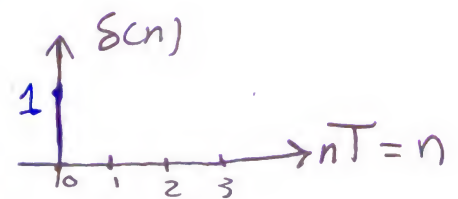
$T=1$   
 $\Rightarrow$



### \* Common discrete signals (sequences)

① unit sample signal (impulse)

$$\delta(n) = \begin{cases} 1, & n=0 \\ 0, & \text{otherwise} \end{cases}$$

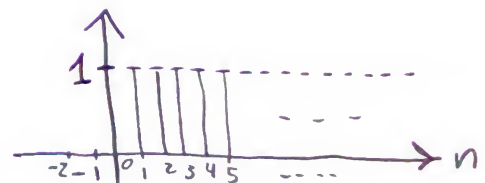


$$\delta(n) = \{ \dots, 0, 0, \underset{\uparrow}{1}, 0, 0, \dots \} = \{ 1 \}$$

$\uparrow \Rightarrow$  indicates  $n=0$

② Unit step signal

$$u(n) = \begin{cases} 1, & n \geq 0 \\ 0, & \text{otherwise} \end{cases}$$



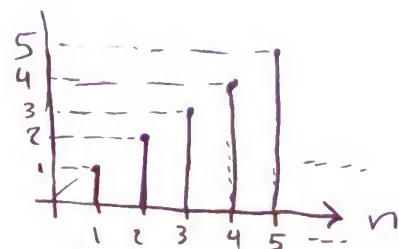
$$u(n) = \{ \dots, 0, 0, \underset{\uparrow}{1}, 1, 1, \dots \}$$

$$= \{ \underset{\uparrow}{1}, 1, 1, 1, \dots \}$$

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③ Unit ramp signal

$$u_r(n) = \begin{cases} n, & n \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

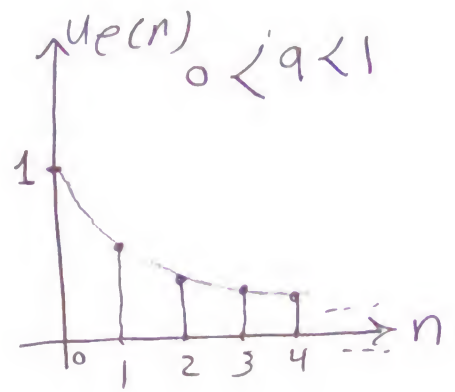


$$u_r(n) = \{ \underset{\uparrow}{0}, 1, 2, 3, 4, 5, \dots \}$$

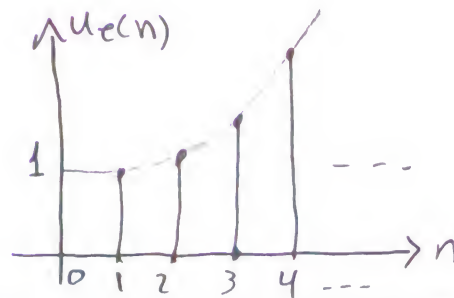
#### ④ Exponential Signal

$$u_e(n) = \begin{cases} a^n, & n \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$u_e(n) = \{ \underset{\substack{\uparrow \\ n=0}}{1}, a, a^2, a^3, \dots \}$$



for  $a > 1$



Ex: given the following sequence:

$$x(n) = \left\{ \underset{-4}{\frac{1}{3}}, \underset{-3}{\frac{1}{2}}, \underset{-2}{-1}, \underset{-1}{0}, \underset{0}{1}, \underset{1}{1}, \underset{2}{2} \right\}$$

① Sketch  $x(n)$

② Find  $x(1), x(2), x(3), x(-1), x(-2), x(-3), x(-4)$

Solution

$$x(1) = 1$$

$$x(2) = 2$$

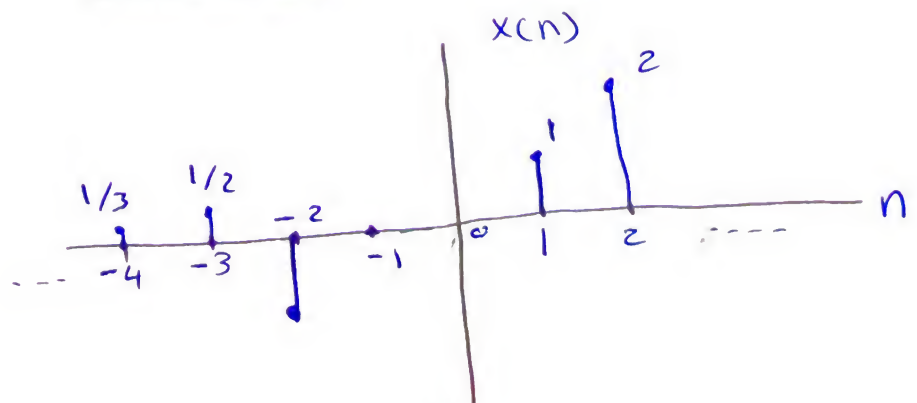
$$x(3) = 0$$

$$x(-1) = 0$$

$$x(-2) = -1$$

$$x(-3) = \frac{1}{2}$$

$$x(-4) = \frac{1}{3}$$



⇒ Turn over



Ex: Find  $\sum_{k=-\infty}^n \delta(k)$

$$x(n) = \sum_{k=-\infty}^n \delta(k) = \dots + \delta(-1) + \delta(0) + \delta(1) + \delta(2) + \dots + \delta(n)$$

$$\left. \begin{array}{l} n=0 \Rightarrow x(0)=1 \\ n=1 \Rightarrow x(1)=1 \\ n=2 \Rightarrow x(2)=1 \end{array} \right\} x(n) = \sum_{k=-\infty}^n \delta(k) = u(n)$$

Ex: Find  $\alpha(n) = \sum_{k=0}^{\infty} \delta(n-k)$

$$\begin{aligned} \alpha(n) &= \delta(n) + \delta(n-1) + \delta(n-2) + \dots \\ &\quad \begin{array}{ccc} \uparrow & \uparrow & \uparrow \\ n=0 & n=1 & n=2 \end{array} \\ &= u(n) \end{aligned}$$

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\* The main operations on discrete signals:-

- ① Shifting operation (delay, Advance)
  - ② Folding (reflection) operation
  - ③ Add operation
  - ④ multiplying operation
- 

Ex:  $x(n) = \{1, 1, 1, 1\}$

Find:  $y_1(n) = x(-n)$

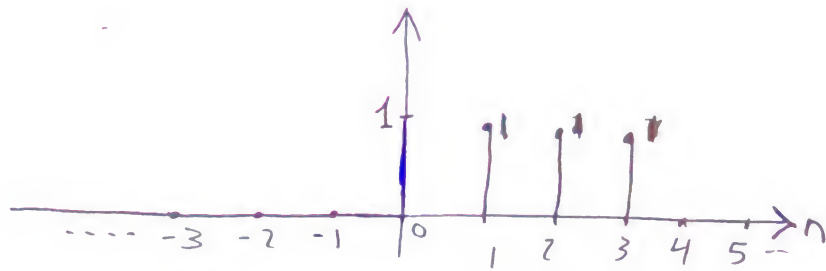
$$y_2(n) = x(n-1)$$

$$y_3(n) = x(n+1)$$

$$y_4(n) = 2x(n)$$

$$y_5(n) = x(n-1) + x(n+1)$$

## Solution



①  $y_1(n) = x(-n)$

$n=0 \Rightarrow y_1(0) = x(0) = 1$

$n=1 \Rightarrow y_1(-1) = x(-1) = 0$

$n=2 \Rightarrow y_1(-2) = x(-2) = 0$

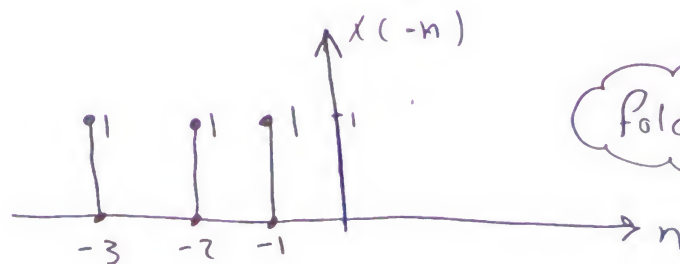
$\vdots$   
 $\downarrow$   
0

$n=-1 \Rightarrow y_1(-1) = x(1) = 1$

$n=-2 \Rightarrow y_1(-2) = x(2) = 1$

$n=-3 \Rightarrow y_1(-3) = x(3) = 1$

$n=-4 \Rightarrow y_1(-4) = x(4) = 0$



folding

②  $y_2(n) = x(n-1)$

$n=0 \Rightarrow y_2(0) = x(-1) = 0$

$n=1 \Rightarrow y_2(1) = x(0) = 1$

$n=2 \Rightarrow y_2(2) = x(1) = 1$

$n=3 \Rightarrow y_2(3) = x(2) = 1$

$n=4 \Rightarrow y_2(4) = x(3) = 1$

$n=5 \Rightarrow y_2(5) = x(4) = 0$

$\vdots$   
 $\downarrow$   
0

$n=-1 \Rightarrow y_2(-1) = x(-2) = 0$

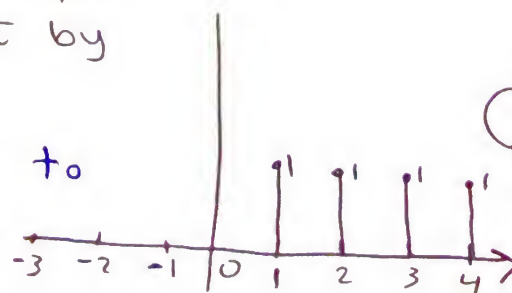
$n=-2 \Rightarrow y_2(-2) = x(-3) = 0$

$\vdots$   
 $\downarrow$   
0

Delay by one sample  
= Shift to right by  
one sample

$x(n-k)$  = shift to  
right by

$k$  samples

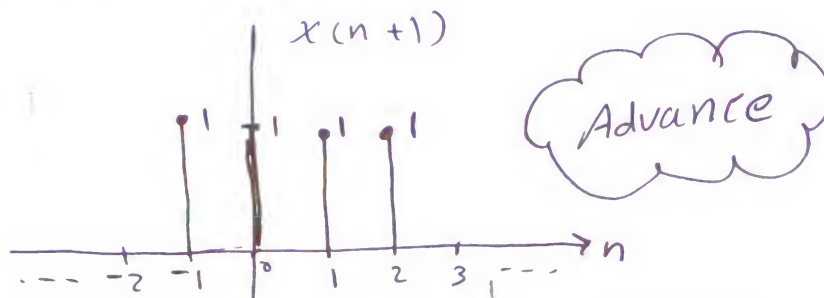


delay

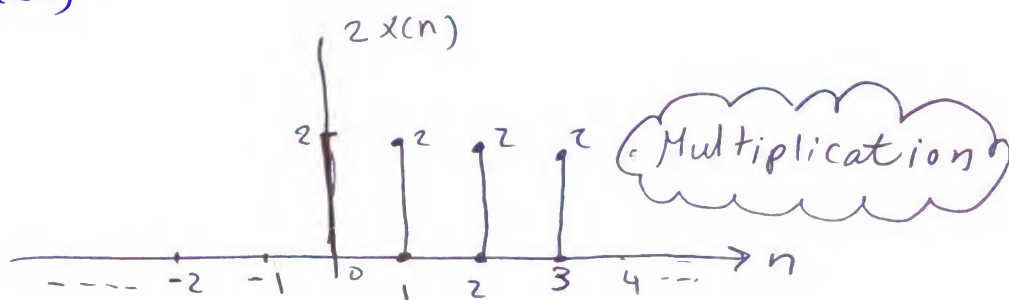
$$\textcircled{3} \quad y_3(n) = x(n+1)$$

Shift to left by one sample

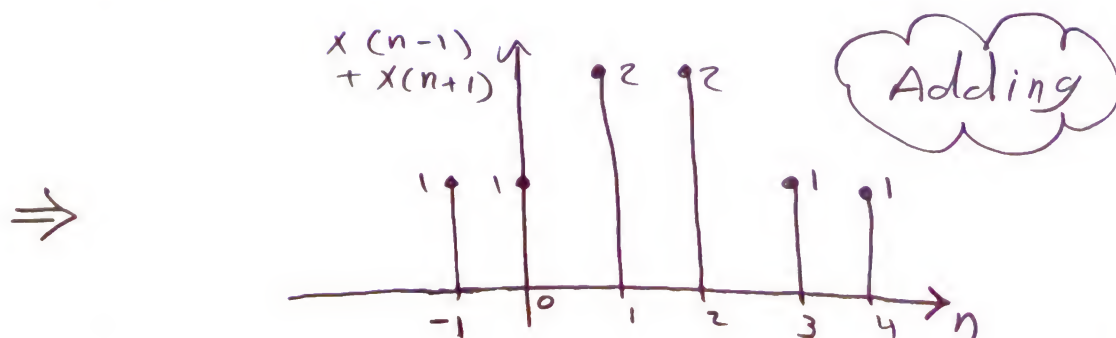
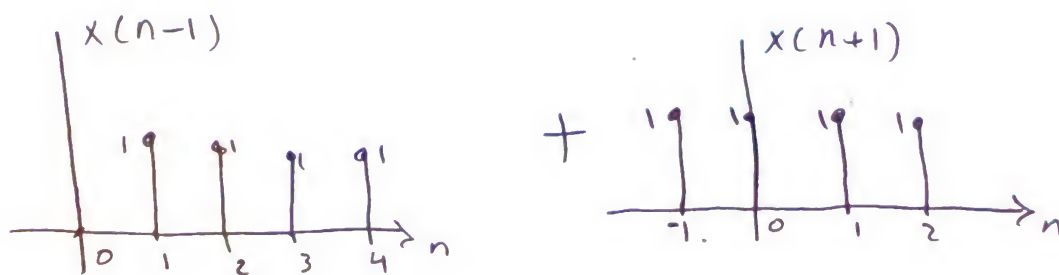
$x(n+k) \Rightarrow$  Shift to Left by  $k$  samples



$$\textcircled{4} \quad y_4(n) = 2x(n)$$



$$\textcircled{5} \quad y_5(n) = x(n-1) + x(n+1)$$



Ex:  $x(n) = \{ \frac{1}{3}, \frac{2}{3}, 1, 1, 1, 1 \}$

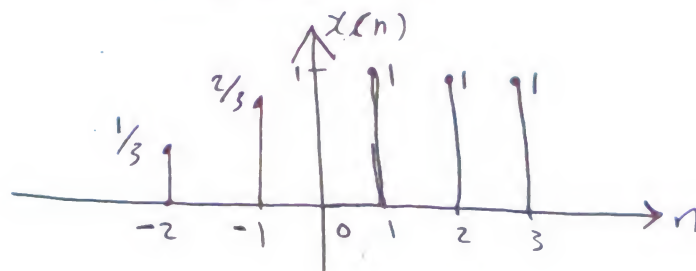
① - sketch  $x(n)$

② - fold  $x(n)$  and then delay by 4 samples

③ - delay  $x(n)$  by 4 samples then fold

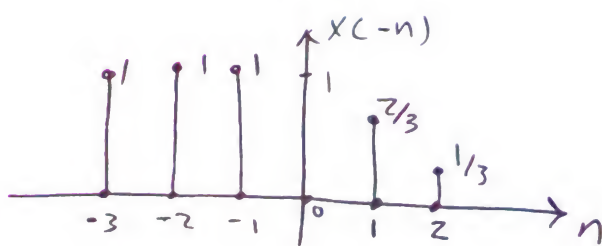
Solution

①

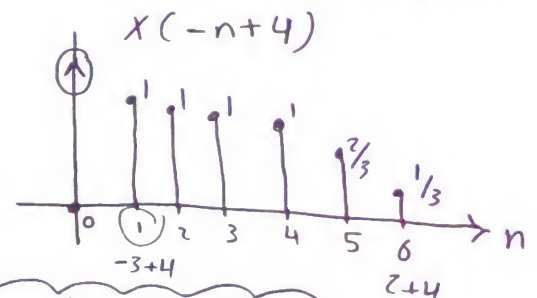


②

fold



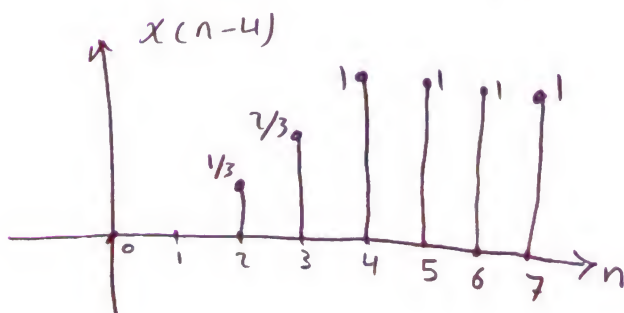
delay by 4 samples



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③

delay by 4 samples



fold

